INPUT TO THE REPORT OF THE HIGH-LEVEL PANEL ON GLOBAL ASSESSMENT OF RESOURCES FOR IMPLEMENTING THE STRATEGIC PLAN FOR BIODIVERSITY 2011-2020

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CLUSTER REPORT ON RESOURCE REQUIREMENTS FOR THE AICHI BIODIVERSITY TARGETS

TARGETS 11 AND 12: PROTECTED AREAS AND SPECIES

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ASSESSING THE FINANCIAL RESOURCES NEEDED TO IMPLEMENT THE STRATEGIC PLAN FOR BIODIVERSITY 2011-2020 AND ACHIEVE THE AICHI BIODIVERSITY TARGETS

Final report from BirdLife International and collaborators on the financial resources needed for Targets 11 and 12

INTRODUCTION

BirdLife International, UNEP-WCMC, RSPB and the Department of Zoology, University of Cambridge, were supported by the Cambridge Conservation Initiative Collaborative Fund to implement a project entitled 'Assessing conservation costs in support of the CBD Strategic Plan' during 1 July 2011 to 31 October 2012. The project also involved collaborators at the University of Copenhagen, World Wildlife Fund, Charles Darwin University, University of Hawai`i, U.S. Fish and Wildlife Service, New Zealand Department of Conservation, and University of Freiburg.

The project aimed to assess the financial costs of conservation actions needed to meet Aichi Targets 11 (preventing extinctions and conserving threatened species) and 12 (expanding and effectively managing protected areas), under the strategic goal 'To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity', building initially on data for birds, the best known class of organisms.

Introduction to the targets

Target 11 states 'By 2020, at least 17 per cent of terrestrial and inland water areas, and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscapes and seascapes'.

For this target, we focussed on the cost of expanding protected areas to cover 'especially areas of particular importance for biodiversity'. 'Key biodiversity areas' (KBAs) represent the only existing global network of such areas that have been systematically identified at the *site* scale (as opposed to much larger and broader *regions* of biodiversity significance, for which there are a number of priority networks globally, e.g. hotspots, ecoregions, wilderness areas etc). KBAs are identified using internationally agreed standardised criteria for threatened, restricted-range, biome-restricted or congregatory species. Among KBAs, the network of 11,731 Important Bird Areas (IBAs, i.e. KBAs identified for birds) is the only globally comprehensive subset (apart from Alliance for Zero Extinction sites, of which there are fewer than 600, with a very restricted total extent, half of which also qualify as IBAs). We used the known relationship between the networks of IBAs and KBAs (in a range of countries in which KBAs have been identified for a broader taxonomic suite of biodiversity, including other vertebrates, and some invertebrate and plant groups) to scale up our funding estimates to cover a theoretical global network of sites of particular importance for biodiversity for a broad range of wildlife.

Previous work has shown that protection of all IBAs would increase the terrestrial protected area coverage to 17.5%, thereby meeting this component of the Target. We did not attempt to assess the costs of expanding *marine* protected areas (as the global inventory of marine IBAs and KBAs is not yet complete).

Target 12 states 'By 2020 the extinction of known threatened species has been prevented and their conservation status, particularly of those most in decline, has been improved and sustained'. The IUCN Red List is widely regarded as the most objective and credible assessment of species in terms of their risk of extinction. We assumed that prevention of extinction and improvement of status of threatened species would be achieved if they were reclassified ('downlisted') to lower categories of threat (extinction risk) on the Red List. Again, we started with data for birds, and then extrapolated this to cover all known threatened species.

Links to other targets

A subset of the actions required to conserve species under Target 12 will involve designation and effective management of protected areas, and hence these overlap with actions needed to meet Target 11. We attempted to assess the extent of this overlap, and a combined cost for the two targets (see below).

We also note that the actions necessary to meet these targets will also deliver substantial contributions to other targets in the CBD strategic plan, as shown in the following examples (with level of confidence in the contribution italicised):

- **Target 5**: Adequate protection and effective management of all KBAs globally would be *highly likely* to make a significant contribution to reducing the rate of loss of natural habitats. Evidence already exists that habitat loss is lower inside IBAs than surrounding areas, for Africa at least (Beresford *et al.* in review).
- **Target 6:** Action to reduce declines and improve the status of threatened seabirds, marine mammals and non-target fish species will *almost certainly* require the problem of marine bycatch to be addressed, thereby contributing to ensuring that 'fisheries have no significant adverse impacts on threatened species'.
- **Target 7**: Many KBAs encompass farmland, managed forests and (to a lesser extent) areas under aquaculture. Hence their effective management (under Target 11) will be *extremely likely* to ensure that 'areas under agriculture, aquaculture and forestry are managed sustainably, ensuring conservation of biodiversity', although the proportion of such production landscapes that fall within KBAs is likely to be small.
- **Target 8**: Prevention of pollution that impacts particular threatened species or individual KBAs will *likely* contribute to bringing global pollution 'to levels that are not detrimental to ecosystem function and biodiversity', although the actions required to achieve Target 8 are likely in general to operate at much broader scales.
- **Target 9**: Action to eradicate and control invasive alien species in order to mitigate threats to species (both within and beyond protected areas) would be *highly likely* make a substantial contribution to this target, which requires 'priority [Invasive Alien] species [to be] controlled or eradicated'.
- **Target 10**: Effective conservation of KBAs will *almost certainly* minimize 'the multiple anthropogenic pressures on…other vulnerable ecosystems impacted by climate change'.
- **Target 14**: Protection of KBAs would be highly *likely* to contribute to safeguarding 'ecosystems that provide essential services, including….[those that] contribute to health, livelihoods and well-being', as called for in this target (Larsen *et al*. 2012).
- **Target 15**: Protection of KBAs would be *likely* to contribute to enhancing 'ecosystem resilience and the contribution of biodiversity to carbon stocks', particularly given the high proportion of KBAs that are found in tropical forests (and the importance of these habitats to carbon storage) (Larsen *et al*. 2012).

TARGET 11: PROTECTED AREAS

ACTIONS

As discussed above, for this target, we focused on the cost of expanding protected areas to cover all KBAs, which previous work has shown would increase the terrestrial protected area coverage to 17.5% (Butchart *et al.* 2012), and the costs of effectively managing all KBAs. We assumed that expansion would entail paying full opportunity costs for establishing new protected areas or expanding existing ones to cover IBAs that are less than fully protected by existing designations. The costs of effective management relate are related to the need to employ adequate numbers of well-trained and equipped staff to undertake the range of on-going activities required to maintain or improve sites and to safeguard them from major threats. Broadly speaking, management costs can be broken down into staff expenses, other regular operational/maintenance costs, recurrent capital costs, and on-going compensation/ incentive payments.

METHOD OF ASSESSMENT

Approach

Our first scenario covered the costs of effectively managing a global network of KBAs. To assess this, we compiled data from various sources on funding requirements for as many IBAs as possible, and then modelled these against socio-economic and site-specific variables to extrapolate costs to all sites. We then extrapolated costs from IBAs to KBAs based on the known areal relationship between the two networks in 12 countries for which suitable data were available. Our second scenario incorporated the costs of expanding protected areas to cover unprotected sites, using a pre-existing global dataset of gross economic rents from agricultural lands as a proxy for conservation costs, again scaling up from IBAs to KBAs.

All estimates were for annual costs to achieve the target over the ten years from 2011 to 2020 inclusive.

Estimating required expenditure for effective site management

We combined data on funding required for effectively managing protected areas from Bruner *et al.* (2004) (converted to 2012 US$ and matched to IBAs) with additional data for 207 sites from 19 countries drawn from IUCN (2002), REMNPAS (2004), Villanueva Ruiz (2005), Evers and Stewen (2006), Schuerholz *et al.* (2007), Grieg-Gran *et al*. (2008), Turpie *et al*. (2009), Ethiopian Wildlife Conservation Authority (2009), WWF Mediterranean Programme (2010), Tua and Nazerali (2010), and Green *et al.* (2012). For Nepal, Philippines, Ecuador, Uganda, and Fiji, data were compiled by BirdLife Partners using structured questionnaires. We removed from the Bruner *et al.* (2004) dataset 108 sites (out of 297) that did not overlap spatially with any IBAs. Our final dataset included site-level management cost data for 396 sites across 50 countries, but owing to missing values for some of the explanatory variables, the final model contained 352 sites from across 47 countries.

To generate estimates for each site for variables that may explain variation in management costs, we overlaid polygons of IBA boundaries with several global-scale spatial datasets, calculating values for each of the variables for both the IBA itself and the surrounding 25-km buffer. We calculated mean human population density (per km^2) using data for 2000 at 0.25 degree resolution from 'Gridded Population of the World' version 3 (Center for International Earth Science Information Network and Centro Internacional de Agricultura Tropical 2005). Using GLC2000 global land cover maps (Bartholomé and Belward 2005), we calculated the proportion of each IBA (and the surrounding buffers) covered by artificial (non-natural/human-dominated) land cover. To measure ease of access/accessibility and pressure, we calculated the density of roads (total length of both primary and secondary roads) surrounding each IBA using VMap0 (National Imagery and Mapping Agency 2012), and mean terrain ruggedness within each IBA (Sappington *et al*.2007) based upon 30 arcseconds global data (23) and a 3×3 cell area. Other variables we used in the modelling were: site area, gross domestic product (GDP) standardized by country area (International Monetary Fund 2012), Purchasing Power Parity (International Monetary Fund 2012) and Human Development Index rank (UNDP 2011).

We used general linear models to model required expenditure per hectare as a function of the socio-economic variables at the country level, and spatially explicit variables at the site-level. Variables were log-transformed to meet assumptions and tested to assess the degree of correlation between them. Where predictors co-varied by more than 0.7, the predictor with the strongest bivariate relationship with the response variable was selected. From the full model, which included all potential predictor variables, all combinations of the predictors were assessed using the 'dredge' function in the MuMin package for R. An information theoretic approach was taken to identify the subset of models whose cumulative Akaike weights summed to 0.95 (Burnham and Anderson (2004). A multimodel average (without shrinkage) was then taken to allow prediction based on the top set of models. Costs were extrapolated to all IBAs using this model.

Extrapolating from IBAs to KBAs

While IBAs have been identified in almost all countries worldwide, globally important sites for biodiversity more broadly (KBAs) have been systematically identified in far fewer countries (Eken *et al.* 2004, Foster *et al.* 2012). Nevertheless, 12 countries have completed inventories for mammals, amphibians and certain reptile, fish, plant and invertebrate groups, and these can be compared to the sites for birds (IBAs) (Butchart *et al*. 2012). Of the sites for non-avian taxa, 71% already qualify as IBAs, covering 80% of the combined area (Butchart *et al*. 2012). We therefore used the areal relationship to extrapolate from costs for IBAs to those for KBAs.

Estimating current expenditure on site management

To estimate current expenditure on site management in lower-income countries, we calculated area-weighted current expenditure per ha by country using information obtained from James *et al.* (1999), REMNPAS (2004), Sector (2006), Bebič and Ogorelec (2008), Turpie *et al.* (2009), TANAPA (2009),, Bovarnick *et al*. (2010), Castillo *et al.* (2012), and Green *et al.* (2012), plus information from UNDP Financial Sustainability Scorecards (sourced online: http://www.thegef.org/gef/gef_projects_funding), with additional data compiled by BirdLife Partners in Ecuador, Nepal, Uganda, Paraguay and Philippines. Where more than one value was available per country, we used the most recent available. Using this information, we calculated the median proportion of required spend currently being met by existing budgets in lower-income countries.

Estimating costs of protecting currently unprotected sites

To assess the costs of establishing or expanding protected areas to cover unprotected IBAs or partially protected IBAs, we used the spatial layer generated by Naidoo and Iwamura (2007) on gross economic rents from agriculture as a proxy for conservation costs (converted to 2012 US$). We obtained site-level data for 5836 of these sites, and used country-level means (2795 sites) or regional-level means (492 sites) for the remainder.

RESULTS & ASSESSMENT OF RESOURCE NEEDS

Extrapolation of our model suggests that the total cost of effectively managing all IBAs worldwide would be US$14.3 billion per year, while a more taxonomically comprehensive global network of KBAs may cost US$17.9 billion annually to manage (US$7.18 for currently protected IBAs, scaling up to US$8.64 for currently protected KBAs, assuming that KBAs are protected to a similar degree as IBAs, on average). Most of this expenditure would be needed in richer countries: only US$4.601 billion annually would be required in lower-income countries (those defined by the World Bank as 'low income' or 'lower-middle income'; World Bank 2012).

We estimated that current annual expenditure on management of existing protected areas in lower-income countries only covers 31% of requirements, leaving a shortfall of US$1.087 billion annually for IBAs, and US$1.45 billion annually when extrapolated to existing protected areas across all KBAs. Incorporating future management costs for currently unprotected/partially protected sites increases the total lower-income country shortfall to US$2.78 billion for IBAs and US$3.94 billion for all KBAs.

Expanding the current protected area network to cover unprotected and partially protected IBAs may cost US$50.7 billion annually, equating to US$58.2 billion annually for a global KBA network (assuming such sites have a similar level of protection as IBAs).

We estimated that the combined costs of expanding protected areas to cover all KBAs and effectively managing all sites would total US$76.1 billion annually. The total for lower-income countries is US$22.4 billion annually.

Table 1. Breakdown of estimated resource needs for Target 11: protected areas.

Activity	One-off investment needs (2011 – 2020)		Recurrent annual expenditure		Recurrent total (2011- 2020)	
	Currently protected sites	Entire KBA network	Currently protected sites	Entire KBA network	Currently protected sites	Entire KBA network
Effectively manage KBAs	n/a	n/a	US$8.64 billion	US$17.9 billion	US$86.4 billion	US$179 billon
Expand protected area network to cover unprotected sites	No data available	No data available	n/a	US$58.2 billion	n/a	US$582 billion
Total			US$8.64 billion	US$76.1 billion	US$ 86.4 billion	US$761 billion

Table 2. Total resource needs for Target 11: protected areas.

Activity	Total for the whole period (2011 – 2020)		Average annual (for period 2011 – 2020)	
	Currently protected sites	Entire KBA network	Currently protected sites	Entire KBA network
Effectively manage KBAs	US$86.4 billion	US$179 billon	US$8.64 billion	US$17.9 billion
Expand protected area network to cover unprotected sites	n/a	US$582 billion	n/a	US$58.2 billion
Total	US$86.4 billion	US$761 billion	US$8.64 billion	US$76.1 billion

DISCUSSION

Discussion of the results

Our overall figures for the costs of protecting unprotected and partially protected sites may be underestimates because we did not include the one-off costs of establishing protected areas that are additional to land acquisition costs, as insufficient data are available to quantify these. These costs include set-up costs (e.g. construction of site infrastructure, establishment of management plans) and associated transaction costs (e.g. stakeholder negotiations, legal costs of gazettement) and may be considerable. We also not include the costs of effectively managing marine protected areas: a previous estimate (adjusted here to 2012 US$) for developing an adequate global marine protected area network suggested this would cost US$6.47-24.6 billion annually (Balmford *et al.* 2004).

On the other hand, the figures for expanding the protected area network may be overestimates because the values from Naidoo and Iwamura (2007) are gross (as opposed to net) potential agricultural rents that assume (i) that maximum potential productivity is achieved across all sites and (ii) that the costs of conversion to agriculture or other types of land-use are minimal. We also note that costs could be reduced in situations where sustainable/multiple-use schemes were adopted, as opposed to strict protection.

The values we calculated for required management costs may also be underestimates as they exclude two important categories of costs: the system-level costs (of administering networks of sites) and the one-off costs associated with bringing existing sites up to an adequate level of management i.e. to overcome the ‘accrued debt’ at some sites that may have resulted from inadequate funding in the past (e.g. site infrastructure and equipment lacking or in poor condition, staff lacking essential skills, habitat heavily degraded etc.). Data from the UK suggest that system level costs could add an additional 24% on top of recurrent management costs, while the additional one-off costs of establishment could be three times higher based on data from Nepal and Ecuador (n=32), but considerably more data are required to develop robust estimates for these components.

We found that a substantial majority of the total costs for expanding protected areas and effectively managing them was required in higher income countries: only 29%—US$22.4 billion annually—is needed in lower-income countries.

A proportion of the costs would be shared between Targets 11 and 12. Site protection and management comprised 50-55% of the total costs for a sample of 211 threatened birds (see below). Discounting this proportion from the total cost of species conservation across all taxa, a combined cost needed to meet both targets may be in the order of US$78 billion annually.

Confidence in the estimates produced

We have relatively high confidence in our estimates of the costs of effectively managing all sites, as these are based on site-specific data from a relatively large sample of 396 sites across 50 countries, extrapolated through a statistical model. As KBAs are identified for non-avian groups in additional countries, further data will become available to strengthen our understanding of the typical area relationship between the subset of IBAs and the wider KBA network. This may modify the factor by which costs for IBAs need to be scaled up to costs for all KBAs.

Our estimates of costs of expanding the protected area network to cover all unprotected sites are based on gross economic rents from agriculture as a proxy for conservation costs, and for 36% of sites these are derived from national or regional means. Hence our confidence in these estimates is moderate, and this component of our analysis would benefit from further validation and improved data.

Additional resource needs

We estimated that current annual expenditure on management of currently protected IBAs and KBAs in lower-income countries falls short of requirements ($2.12 billion) by US$1.45 billion, a 69% shortfall. This compares with previous estimates of the costs of effectively managing protected areas in developing countries of US$1.34-3.05 billion, and estimated shortfalls of US$1.22-2.07 billion (Bruner *et al* 2004). Current expenditure falls short of total needs in lower-income countries (US$4.601 billion) by $3.94 billion, an 86% shortfall.

Further research needs

The principal research needs related to this target are:

(1) Estimates of the costs of establishing protected areas (e.g. capital investment in infrastructure, establishing management plans etc.) and associated transaction costs (e.g. stakeholder negotiations, legal fees, administrative costs etc.).

(2) Improved data on the opportunity costs of site conservation, including validation of the surrogate data used (gross economic rents from agriculture), gap-filling for those countries lacking such data (for which regional means were used in this analysis), and on the costs of conversion. Improved data on the costs of alternative means of safeguard aside from land purchase/acquisition (e.g. community-management, forest certification schemes etc.)

(3) Improved data on the costs of effective management of protected areas, particularly for countries lacking any direct estimates (for which our model extrapolated costs from other countries).

(4) Improved data on the current expenditure on IBA and protected area conservation, particularly in high-income countries (for which insufficient information was available to assess this in the current analysis)

(5) Improved data on non-avian KBAs, including complete inventories in a larger number of countries in order to validate the IBA-KBA relationship used in our analysis.

(6) Research on the costs of meeting this target for the marine environment, as well as for conserving ‘areas of particular importance for…ecosystem services’, improving connectivity between protected areas, and of conservation through ‘other effective area-based conservation measures’ (none of which were considered here).

Table 3. Gap analysis for Target 11: protected areas.

	Target 11: protected areas
Evidence on costs	Low-Medium for costs of protected unprotected sites. Medium-High for management costs. Considerable research is needed to estimate protected area establishment costs. Some research is needed to improve estimates of the costs of protecting unprotected sites. Considerable evidence is needed to assess costs of meeting this target for the marine environment, as well as for conserving ‘areas of particular importance for…ecosystem services’, improving connectivity between protected areas, and of conservation through ‘other effective area-based conservation measures’ (none of which were considered here).
Evidence on current levels of expenditure	Low-Medium Some research is needed to improve estimates of current expenditure in low- and medium-income countries. Considerable research is needed to improve estimates of current expenditure on sites outside national parks in High income countries.
Other Targets	
Links to other Targets	Costs and actions for Target 11 will also contribute to Targets 5, 6, 7, 8, 9,10,14 & 15
Evidence on potential co-benefits	Medium-High Some further research is required to quantify links between Target 11 and other targets
Other policy areas	
Related policy areas outside of biodiversity	Climate change (mitigation and adaptation), human health, agriculture, forestry, food security, energy security, water security

	Target 11: protected areas
Evidence on potential benefits to other policy areas	High potential benefits & high evidence Some further research is required to quantify these benefits

Benefits of delivering the Target

Developing an effectively managed global protected areas network would deliver considerable co-benefits, including major contributions to (a) conservation of genes, populations, species and ecosystems; (b) climate change mitigation (through reducing emissions from habitat conversion and degradation); (c) climate change adaptation (through conserving intact habitats to facilitate accommodation and resilience of biodiversity, and through contributing to ecosystem-based adaptation for people); (d) safeguarding the delivery of a range of other ecosystem services (for both proximate and distant beneficiaries), including, for example, human health (e.g. through medicinal plants), agriculture (e.g. through pollination), forestry (e.g. through ensuring sustainable yields), food security, energy security, water security (e.g. through watershed protection and hydrological regulation) etc.

Funding opportunities / Sources of funding

Domestic government budgets are the single largest source of protected area funding in most countries. In the developing world, many protected areas rely on funding from international agencies and other foreign donors, including multilateral donors (e.g. European Union, World Bank, regional development banks, and Global Environment Fund) and bilateral donors (e.g. USA, Canada, Australia, New Zealand and European countries). Significant funding also comes from private sources, including business and philanthropic foundations as well as non-governmental organizations and local communities. Emerton *et al.* (2006) provide a comprehensive review of sources of funding for protected areas. Emerging opportunities include Payments for Ecosystem Services (PES) schemes, including the UN Reducing Emissions from Deforestation and Forest Degradation (REDD+) programme.

TARGET 12: PREVENTING EXTINCTIONS & CONSERVING THREATENED SPECIES

ACTIONS

To meet this target a suite of actions are required for each threatened species, including site and habitat protection, restoration and management, control/eradication of invasive alien species, species management and recovery actions, trade/harvest management, ex-situ conservation, introduction/reintroduction and education and awareness-raising. We identified the precise actions required for each species in our sample to improve its status sufficiently in order to downlist it to a lower category of extinction risk on the IUCN Red List. We then assessed the costs of each of these.

METHOD OF ASSESSMENT

Approach

To assess the costs of meeting this target, we chose a sample of threatened birds (i.e. those listed as Vulnerable, Endangered or Critically Endangered on the IUCN Red List; BirdLife International 2011), and determined the conservation actions required to prevent their extinction and improve their status. We then asked experts on each species to estimate the cost of each of these actions, and modelled the combined dataset in relation to species-specific variables and socio-economic variables (relating to species' countries of occurrence) to allow us to extrapolate costs across all threatened birds. We considered two scenarios: one in which costs for each species are independent, and one in which we accounted for sharing of costs between co-occurring species. Finally, using data on the relationship between costs for birds and those for other taxa, we extrapolated costs to cover all known threatened species.

All estimates were for annual costs to achieve the target over the ten years from 2011 to 2020 inclusive.

Data sources and species sample

Starting with the list of threatened birds on the 2011 IUCN Red List (BirdLife International 2011), we excluded 15 Critically Endangered species classified as Possibly Extinct or Possibly Extinct in the Wild (i.e. those considered likely to have already gone extinct, but for which confirmation is required; Butchart *et al.* 2006). A further 31 Critically Endangered species have no current known population but are considered extant (Butchart *et al*. 2006, BirdLife International 2011). As further surveys are required before appropriate actions can be identified and implemented for these species, we did not attempt to collect data on the costs of actions for them, but instead predicted their costs from our model (see below). We excluded one Endangered taxon that is now treated as a subspecies: *Apalis (rufogularis) argentea*. We also excluded 122 species listed as Vulnerable under criterion D2 because improving their status to reclassify them as Near Threatened or Least Concern within the next decade is not likely to be feasible: species can qualify under the IUCN Red List criterion D2, if they have very restricted distributions and are hence prone to the effects of human activities or stochastic events such that they are capable of becoming Critically Endangered or Extinct in a very short time period (IUCN 2001). This left a total of 1,115 globally threatened species.

For a sample of 19% of these species, we assessed the costs of the conservation actions needed to improve their status sufficiently to allow them to be reclassified ('downlisted') to lower categories of threat. We used questionnaires sent to relevant experts to collect data on recent and required expenditure on conservation actions for as many Critically Endangered species as possible, and for a stratified sample of Endangered and Vulnerable species (stratified by distribution size and mean GDP of countries within each species' distribution). We also collected data opportunistically on additional Endangered and Vulnerable species. We found no significant differences between the sample of 211 species (105 Critically Endangered, 67 Endangered and 39 Vulnerable species) and 904 unsampled species in any of the variables used in the model (see below), either across all Red List categories or within each Red List category (ANOVA: $P > 0.05$ in all cases).

For each species, experts were asked to provide an estimate (minimum and maximum) of the total amount spent on their conservation (and the conservation of the key sites where they occur) for every year since 2000, and to score their confidence that the true cost fell within their stated range. We converted all values to 2012 US$ using implied GDP deflators (World Bank 2012). For the required expenditure for each species, we determined the change in status necessary to qualify the species for downlisting, given each of the Red List criteria under which the species qualified. We then listed the actions required to achieve this, drawing on those identified in BirdLife International (2001), and categorized following a modified version of Salafsky *et al*. (2008). Respondents modified and/or expanded (with justification) the list, and gave minimum and maximum estimates of the annual cost needed to achieve each action, and the number of years (up to 10, i.e. by the end of 2020) required for implementation. For each estimate of cost, respondents scored their confidence that their estimated ranges contained the true value. Scores ranged from 1 (‘not at all confident/complete guess’) to 5 (‘as confident as a reasonable person can ever expect to be’, with an 80-100% chance of the estimated range of costs including the true cost), following Speirs-Bridge *et al*. (2010). We checked each completed questionnaire to clarify any uncertainties with the expert, and then scaled all respondents’ estimates to a standard degree of confidence (the third of our five categories) using linear interpolation, following Speirs-Bridge *et al*. (2010). We multiplied the adjusted minimum annual cost by the minimum number of years, and the adjusted maximum annual cost by the maximum number of years, and summed across all actions for each species to produce the overall minimum-maximum cost for each species.

Modelling costs

To extrapolate from our sample to the estimated cost for all 1,115 species, we modelled the mid-point between the minimum and maximum cost for each species, weighted by the ratio of each estimate to its range, so that estimates derived from narrower ranges were given greater weight. For 14 cases where experts provided only a single estimate of cost, we set the weight as 1. Where we received responses from multiple experts, we treated each estimate as an independent assessment in the model. We assumed that the costs of species conservation might be a function of species’ traits and of the economic status of the countries they occur in, and that costs would not be independent of range size (distribution extent). We therefore modelled $\log_e$ (mid-range cost) as a function of (a) species traits: 2011 IUCN Red List category, migratory status (yes/no), forest dependence (high/medium/low/does not occur in forest), island endemism (endemic to island(s)/not), breeding (=resident for non-migrants) distribution extent (adjusted by altitudinal distribution limits), and total distribution extent (BirdLife International 2011, Buchanan *et a*l. 2011); and (b) socio-economic indicators of the countries in which it occurs: GDP, per capita GDP, GDP per km^2, and Purchasing Power Parity (PPP, an estimate of the relative cost of living in each country, scaled to USA = 1) (UNDP 2011, International Monetary Fund 2012, World Bank 2012). All possible combinations of these explanatory variables were fitted using the ‘dredge’ function in the MuMIn package in R for model selection and multi-model inference (Bartoń 2012), and used model averaging and ΔAICc values to assess the relative contribution of each explanatory variable. We then used the model to extrapolate costs to the remaining threatened species. For the 31 species with no known population, but considered likely to be extant (see above) we assumed that they were distributed throughout their mapped probable or known ranges (BirdLife International and NatureServe 2011). Three Critically Endangered species (*Ophrysia superciliosa, Rhodonessa caryophyllacea* and *Vanellus macropterus*) are so poorly known that there is no estimate of their distribution size, so we applied the median cost across all Critically Endangered species. The model was extrapolated to all 1,115 species using the ‘predict’ function in R with the ‘se.fit’ option (R Development Core Team 2011). A range of summed estimates was produced by summing exp(estimate – SE) and exp(estimate + SE).

Accounting for cost-sharing

The costs of conservation may be shared among co-occurring species that benefit from the same actions. We accounted for this as follows. We categorised each action as ‘shared’, i.e. potentially benefitting all co-occurring species (e.g. site/area management, invasive/problematic species control, habitat/natural process restoration, site/area protection, education/awareness, law/policy, livelihood/economic and other incentives, and capacity building/training) or ‘unshared’, i.e. benefitting only the target species (e.g. species management—translocations/re-introductions, supplementary feeding, nest box provision, ex situ conservation etc. —research/monitoring, and administrative and other 'undistributed' costs associated with species-level conservation projects). We then calculated the mean proportion of shared and unshared costs for each Red List category. For each species, we divided the shared cost evenly across all equal-area cells in which it occurred, calculated the maximum value across all species in each cell, summed these across all cells and added the sum of unshared costs across all species, using the mean proportion of unshared costs by Red List category multiplied by the modelled total cost for each species outside our sample.

Extrapolating costs to all threatened species

To calculate the cost of conserving all known threatened taxa, not just birds, we calculated that there are 13,452 non-avian threatened species (excluding 404 Possibly Extinct species, 4,102 species listed as Vulnerable under criterion D2, and 546 other marine taxa)), belonging to 37 classes of Animalia, Plantae and Protista (IUCN 2012). This total is 12.06 times larger than the number of threatened birds (excluding Possibly Extinct and Vulnerable D2 species). Hence we multiplied the total estimate of conservation costs for birds (with the minimum value derived from inclusion of cost-sharing, as outlined above, and the, maximum value derived from excluding cost-sharing) by 12.06, divided the product by 4.199 (the factor by which median annual costs for birds are larger than those for other taxa, at least in New Zealand (R. Maloney, Department of Conservation, unpublished data on 664 threatened taxa), and added the total to that for birds. We determined that the New Zealand data are broadly representative of other regions based on a literature review of estimates of the costs of non-avian species conservation. This suggests that costs for mammals are broadly similar to those for birds (median US$1.79 million annually, range US$0.038-105 million annually, n=25 species), but those for other taxa are smaller (e.g. mean US$0.022 million annually for all threatened amphibians), presumably because most other terrestrial taxa tend to have smaller distributions on average.

Estimating recent expenditure & past successes

Data on recent expenditure were provided in all but two of the 236 completed questionnaires (relating to all but one species). These comprised estimates of the amount spent annually on conservation (including site conservation) for the target species for all years in the last decade for which figures were available. We converted all figures to 2012 US$ (see above) and calculated the mean for all years with data. To assess the plausibility of the estimated required costs, we also gathered data on the costs of achieving past downlistings for 25 species (1 Extinct in the Wild, 17 Critically Endangered, 4 Endangered, and 3 Vulnerable species).These species have, as a consequence of conservation interventions, improved in status sufficiently to qualify for downlisting to lower categories of threat since 1988 (Butchart *et al*. 2004, 2010, Hoffmann *et al*. 2010). We asked experts who were involved in implementing these projects to provide estimates of the costs of actions that contributed to the improvement in status. To compare with our estimates of annual required expenditure, we converted the past total costs to cost per year over a 10-year period, and adjusted for inflation (see above).

RESULTS & ASSESSMENT OF RESOURCE NEEDS

Among our sample of 211 threatened birds, the median annual cost per species for conservation actions required to achieve downlisting to a lower category of extinction risk within 10 years was US$0.848 million. This is comparable with the costs of actions undertaken for 25 threatened species that were successfully downlisted during 1988-2008, although the median was significantly lower, perhaps because conservationists often prioritise more tractable species (Donald *et al.* 2010).

For our first scenario, assuming that actions for each species are independent, the total cost of actions required to downlist all1,115 globally threatened bird species was estimated at US$1.23 billion annually over the next decade. For our second scenario, we recognised that most costs are for actions that will probably benefit other species whose distributions overlap, for example, site protection, site management and alien species control/eradication/quarantine. In total, only 20% of the required costs are for species-specific actions such as captive breeding. Accounting for this cost-sharing reduces the total for birds to US$0.88 billion annually (of which US$0.379–0.614 billion is needed in lower-income countries).

Extrapolating these results to cover all ‘known threatened species’ as called for in the target gives a minimum estimate of US$3.41 billion (for scenario 2, if the proportion of costs that are shared among birds is the same for all other taxa), and a maximum estimate of US$4.76 billion (for scenario 1, assuming no cost-sharing).

The median annual expenditure within the last decade for the species in our sample was US$0.065 million (US$0-15.2 million), covering a median of 12.0% of the estimated required annual expenditure per species. Extrapolating this to all bird species suggests that an additional US$0.77-1.09 billion per year is needed (but only US$0.314-0.509 billion in lower-income countries).

Table 4. Breakdown of estimated resource needs for Target 12: preventing extinctions & conserving threatened species.

Activity	One-off investment needs (total period to 2020)		Recurrent annual expenditure		Recurrent total (total period, to 2020)	
	No cost sharing between species	Costs shared between species	No cost sharing between species	Costs shared between species	No cost sharing between species	Costs shared between species
Implement actions needed to downlist known threatened bird species by at least 1 Red List category	The costs of all actions were assumed to be spread evenly over the period		US$1.23 billion	US$0.88 billion	US$12.3 billion	US$8.8 billion
Implement actions needed to downlist all other known threatened taxa by at least 1 Red List category	The costs of all actions were assumed to be spread evenly over the period		US$3.53 billion	US$2.53 billion	US$35.3 billion	US$25.3 billion
Total	None identified		US$4.76 billion	US$3.41 billion	US$47.6 billion	US$34.1 billion

Table 5. Total resource needs for Target 12: preventing extinctions & conserving threatened species.

Activity	Total for the whole period to 2020		Average annual (for period 2011 – 2020)	
	No cost sharing between species	Costs shared between species	No cost sharing between species	Costs shared between species
Implement actions needed to downlist known threatened bird species by at least 1 Red List category	US$12.3 billion	US$8.8 billion	US$1.23 billion	US$0.88 billion
Implement actions needed to downlist all other known threatened taxa by at least 1 Red List category	US$35.3	US$25.3	US$3.53	US$2.53
Total	US$47.6 billion	US$34.1 billion	US$4.76 billion	US$3.41 billion

DISCUSSION

Discussion of the results

The fact that our estimates of the required expenditure for bird species fairly closely matches the known sums spent on actions that led to species being successfully downlisted on the IUCN Red List in the past lends confidence to our estimates. However, extrapolating costs for birds to other taxa involves greater uncertainty. We based our analysis on figures from a dataset in New Zealand. Conservation costs will likely be considerably lower or greater in other countries, but there is no strong reason to expect that the ratio between the costs for birds and those for other taxonomic groups will differ substantially elsewhere. Our review of the literature showed that costs for mammals were broadly comparable, while those for other groups appeared substantially smaller, consistent with the New Zealand data.

For species that occur in the same habitat at the same locations and impacted by the same threats, it is highly likely that they will benefit to a degree from the same actions, and therefore that costs will be shared. The extent of this cost-sharing is not known. Our two scenarios examined two extremes, and it is likely that the real situation falls somewhere between them.

Our estimates of annual costs of species conservation may decline subsequent to the period considered here, given that most projects have higher costs initially, and then lower maintenance costs, and given that costs may decline as understanding and techniques improve (e.g. for captive breeding, or eradication of invasive alien species). Conversely, the costs may escalate, given the resources needed for as-yet unforeseen threats or for adaptation to projected impacts of climate change (Hole *et al.* 2009, 2011, Barbet-Massin *et al.* 2012, Sekercioglu *et al*. 2012), which we did not account for as such impacts largely apply beyond the time-scale we considered.

Our estimates of the costs of actions needed to downlist pelagic threatened seabirds (77, 6.9% of all threatened birds in the analysis) are likely to be underestimates, as we included only the actions needed at breeding colonies on land. We were unable to obtain estimates of the costs of actions required to mitigate threats in the oceans impacting pelagic seabirds, in particular fisheries bycatch (Croxall *et al*. 2012), although current spending (<US$5 million annually) would probably need to be increased by at least two orders of magnitude over the next decade to halt declines (BirdLife International unpublished data).

Target 12 refers to both preventing extinctions and improving the status of known threatened species. Reducing the extinction risk of the species closest to extinction (174 Critically Endangered species) comprises 10.1% of the total cost for birds. However, it is likely that many species will continue to remain reliant on conservation funding beyond any improvement in status (e.g. Scott *et al.* 2010, Redford *et al*. 2011). Indeed, it is more cost-effective in the longer term to ensure that non-threatened species do not become threatened in the first place (Drechsler *et al.* 2011; Wilson *et al.* 2011).

Of the US$0.88-1.23 billion per year required for conservation of threatened birds globally, US$0.379–0.614 billion is in lower-income countries, equating to 43.3-49.4% of the total. If the same proportions applied for threatened species more generally, the total required in lower income countries would be US$1.28-2.39 billion annually.

Confidence in the estimates produced

Our confidence in the estimates of the costs of actions required to improve the status of Critically Endangered species are high, being based on a large proportion of such species. Those for Endangered and Vulnerable species are moderate (and lower for those species with large distributions), as they are based on a relatively small sample. Our confidence of the extrapolated estimates for all known threatened species (i.e. in taxonomic groups beyond birds) are low to moderate, given the relative paucity of direct data on such costs.

Additional resource needs

For the 211 threatened bird species in our sample, a median of 12% of required annual expenditure is currently met, equating to a funding gap of US$ 0.77-1.09 billion per year. Given that the species for which we could obtain data may be biased towards those that are receiving funding, the true shortfall is likely to be even greater. Data are not available to estimate a shortfall for non-avian taxa, but it is likely to be larger still for all groups apart from large mammals, as birds and mammals tend to attract significantly greater conservation investment (Male and Bean 2005, Laycock *et al.* 2009). For example, 83.5% of total spending on species action plans in the UK between 1995-1996 and 2004-2005 was on vertebrates (and 74.8% of this just for birds and mammals) (Laycock *et al.* 2009). In the US, only 12.5% of federal funding for endangered species is spent on plants and invertebrates (Male and Bean 2005).

Further research needs

The principal research needs related to this target are:

(1) Improved data on the costs of actions necessary to downlist: (i) bird species, particularly Endangered and Vulnerable species, migratory species, and those with large distributions (for which relatively few were sampled in the current analysis); and (ii) species in other taxonomic groups

(2) Improved data on current expenditure on species conservation, particularly for species in other taxonomic groups

(3) Improved data on the degree to which costs of actions are shared between species, both within and between taxonomic groups.

Table 6. Gap analysis for Target 12: preventing extinctions and conserving threatened species

	Target 12: preventing extinctions and conserving threatened species
Evidence on costs	Medium-High for costs of bird conservation. Low for costs of conservation for other taxa. Some research is needed to strengthen robustness of estimates of costs of actions for birds. Considerable research is needed to quantify costs of actions for other taxa. Considerable research is needed to identify threatened species systematically in reptiles, fish, invertebrates, plants and fungi.
Evidence on current levels of expenditure	Medium-High for current expenditure on bird conservation. Low for current expenditure on conservation of other taxa. Some research is needed to improve estimates of current expenditure for birds. Considerable research is needed to improve estimates of current expenditure on conservation of other taxa.
Other Targets	
Links to other Targets	Costs and actions for Target 12 will also contribute to Targets 5, 6, 7, 8, 9,10,14 & 15
Evidence on potential co-benefits	Low-Medium Considerable further research is required to quantify links between Target 12 and other targets
Other policy areas	
Related policy areas outside of biodiversity	Climate change (mitigation and adaptation), rural development, health, agriculture, forestry, food security, energy security, water security
Evidence on potential benefits to other policy areas	Moderate potential benefits (particularly through site-based actions) & moderate evidence. Considerable further research is required to quantify these benefits

Benefits of delivering the Target

Preventing extinctions and conserving threatened species would deliver a range of co-benefits. As it would require a considerable component of protecting and effectively managing key sites for threatened species, this would deliver many of the co-benefits listed under Target 11. In addition, individual threatened species may be important for providing ecosystem services such as food (e.g. wild relatives of crop or livestock species), medicine (many threatened plant species), pest control (e.g. mammalian predators of rats, avian predators of pest insects), pollination (e.g. wild bee species), seed-dispersal (e.g. granivorous birds), nutrient recycling (e.g. Asian vultures) and cultural services (e.g. aesthetic and existence values) (see Wenny *et al.* 2011 for a summary for birds; see also Richardson and Loomis 2009).

Funding opportunities / Sources of funding

Significant funding for species conservation is provided by national governments and international agencies. In addition, some global funds are available for threatened species conservation through: the Save Our Species fund (a partnership between IUCN, the Global Environment Facility and the World Bank, with initial financing commitments of US$10 million); the Mohamed bin Zayed Species Conservation Fund (€25 million endowment fund); the Critical Ecosystem Partnership Fund (a joint program of l'Agence Française de Développement, Conservation International, the Global Environment Facility, the Government of Japan, the John D. and Catherine T. MacArthur Foundation, and the World Bank), as well as a host of smaller funding bodies.

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